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WITNESS my hand this
Fifteenth day of July 2004

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PROVISIONAL SPECIFICATION

Invention Title: "Elastic Joint Element and Threaded Fastener Assembly Incorporating Same"

The invention is described in the following statement:

"Elastic Joint Element and Threaded Fastener Assembly Incorporating Same"

Field of the Invention

This invention relates to an elastic joint element for a threaded fastener assembly for securing a work-piece in position. The invention also relates to a threaded fastener assembly and in particular to a threaded fastener assembly that opposes unintentional off-torque. The term "off-torque" as used herein is intended to refer to torque applied to a threaded fastener assembly to loosen or unthread the assembly. The invention also concerns proper fastener preload and the ability to maintain that load.

The invention can provide a high performance threaded fastener assembly capable of withstanding extremely arduous operating conditions, including fatigue loading, thermal loading, shocks and vibration.

One part of the assembly utilises the concept of a positive engagement, spring-loaded clutch for the purpose of preventing undesirable loosening under vibration, while mitigating joint damaging effect of work-piece geometrical imperfections, temperature variations and relaxation under heavy static load. Another part of the assembly, which is typically of a unique conical geometry, helps the assembly cope with fluctuating loads and prevents thread stripping.

Background Art

There have been numerous prior art proposals to render threaded fasteners resistant to unintentional loosening. Typically such proposals involve elements such as wedges, locking ratchets, elastic washers and elastic nuts, all of which have been previously described in prior art, part of them in an undeveloped form or function. The locking action is usually achieved through interaction between joint elements, and in some cases the work-piece. The interaction can be

dynamic (as in the case of locking wedges), static (as in the case of prevailing torque fasteners) or elastic (as in the case of spring washers).

Wedges have been used for more than 100 years for prevention of vibration induced loosening. Elastic washers have been used for damping vibrations and dissipating the energy of shocks. Ratchets have been used for embedding in the clamped work-piece. However, none of the prior art proposals have been entirely effective in providing a controlled locking torque which prevents unintentional loosening of a threaded fastener assembly in service while allowing the assembled fastener to be intentionally unthreaded in a convenient manner.

Specifically, elastic elements of prior art (such as elastic washers) fail to withstand, without flattening (loosing elasticity), the heavy loads of critical applications where fasteners starting with ISO property class 8.8 bolts and class 8 nuts are used.

It is against this background, and the problems and difficulties associated therewith, that the present invention has been developed.

Additionally, the present invention proposes further improvements to solutions, disclosed in patent application PCT/AU01/00255, addressing failures of threaded fastener assemblies and extends its application to other mechanical joints.

The above discussion of the background to the invention is intended to facilitate an understanding of the present invention. However, it should be appreciated that the discussion is not an acknowledgement or admission that any of the material referred to was published, known or part of the common general knowledge in Australia as at the priority date of the application.

Disclosure of the Invention

According to one aspect of the invention there is provided an elastic joint element for a threaded fastener assembly, the elastic joint element comprising a body having a central axis, the body having first and second engaging faces between

which the body can be subjected to compression upon tightening of the threaded fastener assembly, and a central hole extending through the body along the central axis, the body being elastically deformable when subjected to compression, characterised in that the elastic stiffness of the body increases during loading under compression once the body has undergone deflection beyond a predetermined extent.

Preferably, the change in stiffness occurs as a single step.

In a typical threaded fastener assembly involving a bolt and a nut in threaded engagement, the proof load (elastic limit) of the bolt is less than that of the nut. Where the elastic element according to the invention is used in a threaded fastener assembly comprising a bolt and nut in threaded engagement, the stiffness of the body changes from a lower stage to a higher stage, with the lower stage corresponding generally to the elastic range of the bolt and the higher stage being beyond the elastic range of the bolt.

Preferably, the first engaging face is configured for engagement with a rotatable element of the threaded fastener assembly in a manner allowing rotation of the rotatable element in a tightening direction while inhibiting rotation of the rotatable element in the loosening direction. For this purpose, the first face may be equipped with a ramp structure for mating engagement with a complementary ramp structure on the rotatable element, the mating ramp structures cooperating to provide a ratchet mechanism allowing rotation of the rotatable element in the tightening direction while inhibiting rotation in the loosening direction.

The first engaging face may be flat in the sense that it occupies a plane substantially normal to the central axis of the elastic element, or it may be profiled in cross section such as frusto-conical or arcuate.

Where the first engaging face is profiled in cross-section, it is preferably inclined to a plane normal to the central axis of the elastic element at an angle of no more than about 15° to said plane.

It is advantageous to angle the face as it allows centring of the element in relation to the adjacent part of the assembly. The structure may be equipped with interposed ratchet ramps, each having a ramp face and ramp shoulder, a plurality of which makes up a ramp structure. If the elastic element is part of a threaded assembly, the ratchet ramps allow another member of the assembly being in contact therewith to move in the tightening direction and to oppose movement in the unscrewing direction. Such feature in combination with resilient properties of the elastic element allow it behave as a clutch. Consequently, if a torque, bigger than that expected to occur during operation, is applied to the member in contact with the elastic element (either directly or indirectly), in the unscrewing direction, the member will be riding on the ramp shoulder and dropping onto the adjacent ramps, ultimately releasing tension in the assembly. To allow such behaviour ramp shoulder needs to be inclined such that its pitch should be smaller than twenty times the pitch of the thread.

The elastic joint element may be constructed such a way that torque transferred through the engaging face during unscrewing is bigger than that transferred through the ramp structure.

The geometry of the elastic joint element allows it to withstand many times the forces which prior art resilient discs and washers can withstand, as specified in DIN 6796. Further, the elastic joint element features the changing stiffness characteristic. Such a characteristic, which is generally linear relationship of forces as a function of deflection has certain inclination leading towards proof load of externally threaded element of the joint. Further loading beyond that value results in lesser elongation per unit force.

Means may be provided for reducing frictional resistance between the mating ramp structures during relative movement therebetween corresponding to tightening of the threaded fastener assembly. Such means may take any appropriate form, such as a lubricant therebetween or the provision of rollers facilitating relative movement therebetween at lower frictional resistance.

Preferably, the second engaging face is configured for engagement with a work-piece.

Preferably, the second engaging face includes a curved configuration. The curved configuration may involve concavity and a point of inflection at which the concavity reverses, the concavity being inwardly facing on the radially outerside of the point of inflection and outwardly facing on the radially inwardly side of the point of inflection.

The second engaging face preferably further includes a flat section and a further section radially inward of the flat section, the further section being of said curved configuration.

Preferably, the body further includes a flange portion extending inwardly to an inner periphery thereof extending around the central hole, the inner periphery being at a diameter smaller than the inner diameter of each of the engaging faces.

Preferably, the curved configuration of the second engaging face merges with the flange portion.

The body of the elastic element may be equipped with means for providing an indication of the extent of relative rotation between the rotatable element and the elastic element following initial engagement therebetween. The indication may be of any appropriate form, such as a visual indication, an acoustic indication or a combination thereof.

According to a second aspect of the invention there is provided a threaded fastener assembly incorporating an elastic element according to the first aspect of the invention.

In one arrangement, the elastic element comprises a washer. The washer and the adjacent component of the threaded fastener assembly with which the washer engages, preferably have mating surfaces profiled to provide an interface

which acts to centrally align the component and the washer with respect to the central axis thereof.

According to a third aspect of the invention there is provided an elastic joint element comprising a body having a central axis including two opposed sides, an outer periphery, an inner periphery defining a central aperture, one opposed side being provided with a structure for interaction with an adjacent component of a joint assembly to provide a mechanical connection therebetween, the other opposed side defining a further engaging face including a curved configuration.

The curved configuration may involve concavity and a point of inflection at which the concavity reverses, the concavity being inwardly facing on the radially outerside of the point of inflection and outwardly facing on the radially inwardly side of the point of inflection.

The further engaging face preferably further includes a flat section and a further section radially inward of the flat section, the further section being of said curved configuration.

Preferably, the body further includes a flange portion extending inwardly to an inner periphery thereof extending around the central hole, the inner periphery being at a diameter smaller than the inner diameter of each of the engaging faces.

Preferably, the curved configuration of the second engaging face merges with the flange portion.

Preferably said opposed side provided with a structure for interaction with a component of a joint assembly to provide a mechanical connection therebetween, may be profiled in cross-section to accommodate the adjacent component. The profiling may be of any appropriate form, such as a taper.

According to a fourth aspect of the invention there is provided a threaded fastener assembly for releasably securing a work-piece in position, the threaded

fastener assembly comprising a threaded fastener having an axis of rotation, an elastic element (such as an elastic washer) presenting an annular engaging face concentric with said axis of rotation for engaging the work-piece, means providing a mechanical connection between the threaded fastener and the elastic element facilitating rotation of the threaded fastener relative to the elastic element in a tightening direction while resisting relative rotation in a loosening direction, the threaded fastener comprising an assembly of first and second fastener members, the first fastener member comprising a head portion and a projection portion extending axially from the head portion, with an engaging face on the head portion surrounding the projection portion, the second fastener member comprising a first engaging face, a second engaging face and a central hole for receiving the projection portion of the first fastener member with a clearance fit and with the engaging face of the first fastener member in engagement with the first engaging face of the second fastener member, the second engaging face of the second fastener member being in engagement with the elastic element.

Preferably, the engaging face of the first fastener member and the first engaging face of the second fastener member are provided with a mechanical connection therebetween for coupling the first and second fastener members together for rotation in unison when the first fastener member is rotated in the tightening direction. The mechanical connection may, in one arrangement, also couple the first and second fastener members together for rotation in unison when the first fastener member is rotated in the unscrewing (loosening) direction. Alternatively, the mechanical connection may, in another arrangement, be adapted to urge the first and second fastener members axially apart in response to rotation of the first fastener member relative to the second fastener member in the loosening direction.

Where the mechanical connection couples the first and second fastener members together for rotation in unison when the first fastener member is rotated in the unscrewing (loosening) direction, the connection may be provided by any appropriate structure, such as for example inter-engaging grooves or the like,

which provide a spline connection between the first and second fastener members.

Where the mechanical connection is adapted to urge the first and second fastener members axially apart in response to rotation of the first fastener member relative to the second fastener member in the loosening direction, it may comprise a ramp structure on the second engaging face of the second fastener member and a complementary ramp structure on the elastic element, the mating ramp structures providing a ratchet mechanism allowing rotation of the first fastener member in the tightening direction while inhibiting rotation in the loosening direction.

Preferably, the mechanical connection between the first and second fastener members comprises a ramp structure on each of the engaging surfaces. With this arrangement, the ramp structures cooperate to provide a wedging action for wedging the first and second fastener members axially apart in response to rotation of the first fastener member in the loosening direction. Typically, the wedges have a pitch greater than the pitch of threads of the threaded fastener, whereby rotation of the first fastener member in the loosening direction causes the threads to jam and consequently inhibit further rotation in the loosening direction.

The elastic nature of the elastic element allows it to undergo compression to provide freedom for the fastener assembly to be unthreaded without damage thereto.

The elastic element is preferably in accordance with the first aspect of the invention.

The fastener may comprise a bolt or a nut.

Where the fastener is a nut, the hole therein for threadingly engaging a bolt extends through both the head portion and the projection portion, with the hole being internally threaded throughout the full length thereof. This arrangement

provides for a nearly even load distribution along the threads in comparison to conventional nuts where the majority of the load is taken by the first few threads.

Preferably, the projection portion of the first fastener member is generally tapered inwardly towards the free end thereof, and the hole within the second fastener member is correspondingly shaped while also maintaining a clearance fit therebetween.

Preferably, the second engaging face of the second fastener member is larger than the first engaging face thereof. This is advantageous as it provides a larger area at the interface between the fastener and the elastic element to accommodate the ramp structure.

The face of the elastic element engaging the work-piece may be provided with means for inhibiting rotation of the elastic element relative to the work-piece. Such means may comprise one or more discrete embedding protrusions on the elastic element adapted to embed in the work-piece at low loads. Each embedding protrusion may be defined by an integral tooth configured to embed in the work-piece. With this arrangement, the work-piece is embedded locally to prevent any relative movement which might otherwise cause the embedding portions to plough along the work-piece surface causing damage.

The threaded fastener assembly may be provided with means for providing a visual indication of the extent to which the threaded fastener assembly is preloaded. This may be achieved by way of a scale allowing the extent of rotation of the fastener relative to the elastic element to be determined after initial frictional contact therebetween. It is the extent of such rotation that determines the preload on the threaded fastener assembly.

Because of the ratchet engagement between the fastener and the elastic element, there is a "clicking" noise generated upon rotation of the fastener relative to the elastic element in the tightening direction after initial engagement therebetween. Such "clicking" noise can be utilised to regulate the extent of preload on the fastener assembly, as each "click" corresponds to a specific

amount of angular rotation of the fastener and hence a specific incremental force imposed thereby. For example, in a particular fastener assembly it may be specified that tightening should be to a prescribed number of "clicks" in the assembly. In circumstances where it is difficult for a user to hear the "clicks", a sound pick up device (such as an acoustic-electric transducer or microphonic device) may be employed. Such a device may incorporate amplification and/or control circuitry.

According to a fifth aspect of the invention there is provided a threaded fastener assembly for releasably securing a work-piece in position, the threaded fastener assembly comprising a threaded fastener having an axis of rotation, the threaded fastener presenting an annular engaging face concentric with said axis of rotation for engaging the work-piece or another component of the threaded fastener assembly, the threaded fastener comprising an assembly of first and second fastener members, the first fastener member comprising a head portion and a projection portion extending axially from the head portion, with an engaging face on the head portion surrounding the projection portion, the second fastener member comprising an engaging face and a central hole for receiving the projection portion of the first fastener member with a clearance fit and with the engaging face of the first fastener member in engagement with the engaging face of the second fastener member, said annular engaging face being provided on the second fastener member on the opposed side thereof the engaging face.

Preferably, the threaded fastener further comprises means providing a mechanical connection between the first and second fastener members for coupling them together for rotation in unison when the first fastener member is rotated in the tightening direction. The mechanical connection may, in one arrangement, also couple the first and second fastener members together for rotation in unison when the first fastener member is rotated in the unscrewing (loosening) direction. Alternatively, the mechanical connection may, in another arrangement, be adapted to urge the first and second fastener members axially apart in response to rotation of the first fastener member relative to the second fastener member in the loosening direction.

Where the mechanical connection couples the first and second fastener members together for rotation in unison when the first fastener member is rotated in the unscrewing (loosening) direction, the connection may be provided by any appropriate structure, such as for example inter-engaging grooves or the like, which provide a spline connection between the first and second fastener members.

Where the mechanical connection is adapted to urge the first and second fastener members axially apart in response to rotation of the first fastener member relative to the second fastener member in the loosening direction, it may comprise a ramp structure on the second engaging face of the second fastener member and a complementary ramp structure on the elastic element, the mating ramp structures providing a ratchet mechanism allowing rotation of the rotatable element first fastener member in the tightening direction while inhibiting rotation in the loosening direction.

The threaded fastener assembly according to the fourth and fifth aspects of the invention can each provide an elastic nut and washer assembly which complement the elastic joint element and which can also be a valuable proposition in combination with common, as well as new, elements of a threaded fastener assembly.

Such an elastic nut and washer assembly is an important concept in fasteners as it could solve the problem of thread stripping and fatigue failure. The above failure modes result from overstressing sections of the thread that propagates once the stripping has been initiated. Axial loads tend to increase the thread pitch of externally threaded fasteners with the corresponding decrease of pitch of the nut causing overloading of the first engaged threads. Building a nut with conical section that extends below its bearing surface converts it to partially tensile member with vastly improved load transfer. Such a fastener can withstand fluctuating loads other fasteners on the market cannot. Stress concentrations also occur at the head of the bolt. Adaptation of the elastic nut geometry to bolts and extending it further to other externally threaded parts will

equally improve their performance. It is also beneficial to use a combination of an elastic nut and elastic bolt together within the same assembly.

Despite obvious advantages of the concept there are no elastic nuts or bolts on the market. Embodiments of this invention disclose a design that can be built and mass-produced. It proposes to split the known 'concept nut' into an elastic nut-washer assembly comprising parts that are mechanically locked. The locking mechanism might be of any appropriate form, such as grooves or ramps, for example, wedges and ratchets. Ratchets have been already described in conjunction with an elastic joint element. Wedges are formed in opposite to ratchets direction. Their shoulders engage during tightening process and ramp faces ride upon each other during unscrewing to wedge threads and dynamically lock them.

The central aperture of the washer follows the conical shape of the nut. The obvious advantage of such a form is a one-way fit, so there is no need for pre-assembly or gluing for proper installation. Another advantage is improved geometry that alleviates stresses.

All of the above-described elastic elements will combine their advantages when used together making common elastic joints. In fact a number of elastic elements can be assembled in series, parallel and their combination, very much as conventional conical washers are assembled to increase deflection or loading capability.

It is increasingly widely understood that locking system cannot compensate for under tensioned fasteners. Therefore embodiments of this invention discloses not only how to reliably lock fasteners but also how to accurately preload them and make them hold this tension while exposed to the most severe environmental conditions like shocks, vibration and changing temperatures. One of such mechanisms is a scale and a pointer, as previously mentioned. They can be placed against each other on such parts that relatively rotate. Since forces in threaded assemblies are directly proportional to the angle of rotation it is sufficient to read the scale to be able to preload fasteners with accuracy far

better than with the use of a torque range. The only tool required is a simple spanner.

Another method contemplated here is an acoustic device that picks-up the clicking noise generated during preloading by parts rotating on ratchets. There could be a vast number of possible devices that can be adopted, as referred to previously. Starting from the simplest amplifiers that help a fitter to count the clicks, to complex instruments that totalise clicks until preset loading is achieved.

A part common to all the disclosed assemblies is the elastic joint element functioning as a retainer washer that is in the immediate contact with a work-piece. For proper operation of the assembly, the retainer washer needs to have a sufficiently large diameter or other means that hold it in steady position. One such other means may comprise embedding protrusions, as referred to previously. Only few of such protrusions are necessary and they do not damage the opposite surface other than causing partly elastic indents, because they do not rotate against the work-piece surface, but are pushed in by other parts rotating on the washer.

This invention also contemplates use of multiple-start threads that can be utilised here to their best advantage since none of the proposed assemblies relies on thread's friction for holding it against unscrewing. With the use of friction reducing method a mechanical advantage can be the same with a much bigger thread pitch than used in present art fasteners assemblies.

To reduce friction on ratchets beyond a static friction, there may be use of roller bearings. Such roller bearings can be implemented in a number of different ways, some of which are described in more details in further sections of this disclosure.

The use of an elastic element provides an elastic assembly that can hold an imposed pre-tension over a long operational life without retightening while not only standing up to but also accommodating to the most severe operational environment.

According to a sixth aspect of the invention, there is provided an elastic washer-fastener assembly as set forth herein which may be used either with or without additional washers.

Brief Description of the Drawings

The invention will be understood by reference to the following description of several specific embodiments thereof as shown in the accompanying drawings in which:

Figure 1 is a perspective view of an elastic joint element according to a first embodiment;

Figure 2 is a schematic fragmentary view illustrating the configuration of a ramp structure providing ratchets on the elastic joint element;

Figure 3 is a graph showing the load characteristics of the elastic joint element in terms of compressive force versus deflection;

Figure 4 is a schematic cross-sectional view of the elastic joint element showing compressive deformation thereof at several stages of loading;

Figure 5 is a detailed view of part of the elastic joint element illustrating its condition at said several stages of loading;

Figure 6 is a cross-sectional view of the elastic joint element;

Figure 7 is a fragmentary cross-sectional view of the elastic joint element;

Figure 8 is a fragmentary cross-sectional view, showing an alternative configuration of an engaging face of the elastic joint element;

Figure 9 is a fragmentary cross-sectional view, showing a further alternative configuration of an engaging face of the elastic joint element;

Figure 10 is a perspective view of a threaded fastener assembly according to a second embodiment, the threaded fastener assembly comprising a nut assembly;

Figure 11 is a perspective view from the underside of a first nut member forming part of the nut assembly;

Figure 12 is a schematic cross-sectional view illustrating loading of the nut assembly (the nut assembly being illustrated as one-piece for the purposes of clarity);

Figure 13 is a graph of low distribution along the engaging threads of the fastener assembly, with the nut construction illustrated in Figure 12 as compared to a conventional nut construction;

Figure 14 is a perspective view from the upperside of a second nut member forming part of the nut assembly;

Figure 15 is a perspective view from the underside of the second nut member;

Figure 16 is a cross-sectional view of the threaded fastener assembly fitted onto an externally threaded fastener such as a bolt;

Figure 17 is an underside view of the elastic joint element, showing the contacting face thereof for engagement with a work piece;

Figure 18 is a cross-sectional view of a threaded fastener assembly according to a second embodiment;

Figure 19 illustrates an alternative arrangement where the nut assembly is replaced with an externally threaded fastener assembly;

Figure 20 is a partly exploded perspective view of a threaded fastener assembly according to a further embodiment, the threaded fastener assembly comprising a nut assembly;

Figure 21 is a cross-sectional view of the threaded fastener assembly of Figure 20;

Figure 22 is a perspective view of the underside of a first member forming part of the nut assembly;

Figure 23 is a perspective view from the upperside of a second member forming part of the nut assembly;

Figure 24 is a cross-sectional view of a threaded fastener assembly according to a still further embodiment, incorporating a plurality of elastic elements arranged in series;

Figure 25 is a perspective view of a threaded fastener assembly according to a still further embodiment;

Figure 26 is a perspective view of an elastic washer forming part of the threaded fastener assembly of Figure 25;

Figure 27 is a perspective view of a first member of a nut assembly, with the first member being internally threaded using a multiple-start thread;

Figure 28 is a schematic side elevational view (partly in section) of a threaded fastener assembly according to a still further embodiment; and

Figure 29 is a schematic perspective view of an elastic joint element incorporating a modified construction of ratchet arrangement.

Best Mode(s) for Carrying Out the Invention

Referring now to Figures 1 and 7 of the accompanying drawings, there is shown an elastic joint element 400 according to a first embodiment for use in a threaded fastener assembly which provides a joint.

The elastic joint element 400 of this embodiment comprises a washer having a generally annular body 490 with a first engaging face 492 for engagement with a component of a threaded fastener assembly (such as a nut), and a second engaging face 491 for engagement with a work-piece. The annular body 490 has a central axis, with the engaging faces 491, 492 each being of an annular configuration centred on the axis. The body 490 has a radial outer periphery 493 and a radial inner periphery 494 defining an aperture, which is centrally disposed with respect to the axis and which extends between the two engaging faces 491, 492.

The first engaging face 491 is of frusto-conical configuration, being disposed at an angle to a plane normal to the central axis of the elastic element. This provides the elastic element 400, and a complementarily-shaped component in engagement therewith, with a "self-centring" function. Other arrangements are, of course, possible. One such other arrangement is illustrated in Figure 8 of the drawings where the face 491 is substantially flat and normal to the central axis of the elastic element 400. Another arrangement is illustrated in Figure 9 where the face 491 is arcuate in cross section. The face 491 is adapted for engagement with the component of the threaded fastener assembly in a manner allowing rotation of the fastener component in a tightening direction while inhibiting rotation in the loosening direction. For this purpose, the engaging face 491 is equipped with a structure 700 for mating engagement with a complimentary ramp structure on the fastener component. The engaging structures cooperate to provide a ratchet mechanism allowing rotation of the fastener component in the tightening direction while providing controlled rotation in the unscrewing direction. Controlled rotation in the unscrewing direction prevents unintentional loosening

of the threaded fastener assembly in service while allowing the assembled fastener to be intentionally unthreaded in a convenient manner.

The structure 700 has interposed ratchet ramps 748, each having a ramp face 745 and ramp shoulder 746 defining a ramp structure 740.

To allow ratchet clutch action (as will be explained in more detail later), the shoulder 746 of the ratchet ramp is inclined in the threading direction, sloping with a pitch higher than thread's pitch not exceeding 20 times value of thread pitch.

The elastic joint element 400 undergoes compression between the first and second engaging faces 491, 492 upon tightening of the threaded fastener assembly in which the elastic element 400 is incorporated. The body 490 is constructed to be elastically deformable when subjected to such compression, with the compression having the characteristic that the elastic stiffness of the body increases in a single step during loading under compression.

The behaviour of the elastic joint element 400 during loading is depicted in Figure 3, where deflection on horizontal axis is plotted against forces on vertical axis. The point of directional change in the plotted line represents the single step increase in elastic stiffness of the body. Force of 100% represents proof load of an internally threaded part of the joint, which causes 100% deflection on the graph. However this deflection does not need to completely flatten the elastic element. The horizontal line that crosses the graph represents force equivalent to proof load of externally threaded part. It can be seen that characteristic conveniently stiffens in that area allowing the element to withstand huge forces going far beyond these depicted on the graph without plastic deformations within the element.

The variation in stiffness exhibited by the elastic joint element 400 is attained by virtue of the construction of the body 490. Specifically, the second engaging face 492 is of a construction involving a flat section A and a curved section B, as indicated in Figures 7 and 8. The curved section B has concavity and a point

inflection C at which the concavity reverses. With this arrangement, the curved section B is generally of a "sloping s" configuration in cross-section, as best seen in the drawings. The concavity is inwardly facing with respect to the body 490 on the radially outer side of the point of inflection, and outwardly-facing on the radially inward side of the point of inflection. With this arrangement, the second engaging face 492 presents a convex portion D facing the work-piece and a concave portion E, also facing the work-piece, with the convex portion D being closer to the work-piece and progressively moving into engagement with the work-piece as the elastic washer undergoes compression, as shown in Figures 4 and 5 where various positions of the second engaging face are illustrated. From the drawings, it can be seen that the area of the convex portion D in engagement with the work-piece, progressively increases with increasing deflection of the elastic joint element.

The body 490 further includes a flange portion F extending inwardly at the inner periphery of the body to extend around the central aperture. The radial inner periphery 494 of the body defined by the flange portion Z is at a diameter smaller than the inner diameter of each of the first and second engaging faces 491, 492.

The curved configuration of the second engaging face 491 merges with the flange portion F.

The behaviour of the elastic element is explained with reference to Figures 4 to 6. Figure 4 represents a theoretical, exaggerated cross-sectional shape and Figure 5 one of possible implementations. Such a shape delivers superior elastic properties, contributing generally linear behaviour. The flange portion F holds the radial outer face 493 in position, preventing excentric movement during loading as is the case with present art conical springs. Both figures show changing shape of the element during loading.

Referring now to Figures 10 to 19 of the accompanying drawings, there is shown a threaded fastener assembly according to a second embodiment. The threaded fastener assembly comprises a nut assembly 100 for threadingly engaging a bolt,

and also an elastic element 400 of the type according to the first embodiment, the threaded fastener assembly being best seen in Figure 18 of the drawings.

The nut assembly 100 comprises two parts, being a first nut member 290 and a second nut member 590.

The first nut member 290 comprises a head portion 210 and a projection portion 280 extending axially from the head portion, with an engaging face 211 on the head portion surrounding the projection portion. The outer periphery of the head portion 290 is provided with means to facilitate turning thereof, such as wrenching flats in the manner of a conventional nut for the purposes of engagement by way of a spanner or wrench.

The projection portion 280 has an outer radial periphery surface 283 tapering inwardly towards the free end of the projection portion.

The first nut member 290 has a threaded hole 234 therein for threadingly engaging an externally threaded fastener such as a bolt as identified by reference numeral 300. The thread extends through both the head portion 210 and the projection portion 280. This arrangement provides for a nearly even load distribution at the threaded engagement between the nut 290 and the bolt, in contrast to conventional nuts where the majority of the load is taken by the first few threads. The manner of threaded engagement between the nut 290 and the bolt 300 is illustrated schematically in Figure 10 of the drawings (noting, however, that the nut 290 is not illustrated in its two-part construction). Figure 11 is a graph of load distribution along the engaging threads between the nut 290 and the bolt, with the relationship being depicted by the broken line. The graph also includes, for the purposes of comparison, a representation of the load distribution in a conventional nut and bolt, such representation being by way of the solid line in the graph.

The second nut member 590 comprises a body W having a first engaging face 591 for facing engagement with the engaging face 211 of the first nut member 290, and a second engaging face 592 for facing engagement with the first

engaging face 492 of the elastic washer 490. The body W further includes a central hole 594 for receiving the projection portion 280 of the first nut member 290 with a clearance fit therebetween, as best seen in Figure 16 of the drawings.

The second engaging face 592 is larger than the first engaging face 591 in order to provide a larger area at the interface between the second nut member 590 and the elastic element 490 to accommodate the ratchet mechanism operating therebetween.

The first nut member 290 and the second nut member 590 are in facing engagement through their respective faces 211, 591. A mechanical connection is provided between the first nut member 290 and the second nut member 590 for coupling them together for rotation in unison when the first nut member is rotation in the tightening direction, and for urging the first and second nut members axially apart in response to rotation of the first nut member relative to the second nut member in the loosening direction. The mechanical connection is provided by a ramp structure 240 on the engaging face 211 of the first nut member 290 and a complimentary ramp structure 540 on the engaging face 591 of the second nut member 590. The ramp structures 240, 540 cooperate to provide a wedging action for wedging the two nut members 290, 590 axially apart in response to rotation of the first nut member 290 in the loosening direction. For this purpose, each ramp structure 240, 540 comprises a series of wedge sections 749 having a wedge pitch greater than the pitch of threads, whereby rotation of the first nut member 290 in the loosening direction causes the threads to jam and consequently inhibits further rotation in the loosening direction.

The second engaging face 592 of the second nut member 590 is provided with the ratchet structure (referred to earlier) for cooperative engagement with the ratchet structure on the elastic washer, as described previously.

The facing surfaces at which there is engagement between the first and second nut members 290, 590 are configured for centering alignment therebetween. This is achieved by having the surfaces of frusto-conical configuration.

Similarly, the facing surfaces between the elastic washer 400 and the second nut member 590 are also configured for centering therebetween. Again, this is achieved by having the facing surfaces of frusto-conical configuration.

To keep the assembly reasonably compact, the retainer washer 400 might need to be equipped with embedding protrusions 077 on the face 070 thereof, as evident from Figure 17.

In the embodiment previously described, the fastener element was in the form of a nut assembly 100. It should be understood that the fastener element can also be in the form of a bolt, with the head of the bolt being of two part construction along similar lines to the nut assembly 100. Figure 19 of the drawings illustrates the first member 390 of the bolt. The first member 390 comprises a head portion 310 and a projection portion 380 extending axially from the head portion, with an engaging face on the head portion surrounding the projection portion. The threaded shank of the bolt extends from the projection portion, as shown in the drawing.

In the embodiment described previously, the thread fastener assembly comprised the nut assembly 100 of two-part construction, as well as the elastic element 400.

The embodiment shown in Figures 20 to 23 uses some of the characteristics of the previous embodiment in that it incorporates an assembly 100 which provides a nut 290 and a retainer washer 490. In this embodiment, however, the nut 290 incorporates the features of the first nut member 290 of the earlier embodiment, and the retainer washer 490 is constructed so as to incorporate the features of the second nut member 590 of the earlier embodiment.

In this way, the nut assembly 100 is still of two-part construction, one part being the nut member 290 and the other part being the retainer washer 490 which performs the function of the second nut member as well as a washer.

The nut member 290 comprises a head portion 210 and a projection portion 280 extending axially from the head portion, with an engaging face 211 on the head portion surrounding the projection portion. The projection portion 280 has an outer surface tapering inwardly towards the free end of the projection portion.

The nut member has a threaded hole therein for threadingly engaging the bolt. The thread extends through both the head portion 210 and the projection portion 280. This arrangement provides for a nearly even load distribution at the threaded engagement between the nut member 290 and the bolt, as was the case with the earlier embodiment.

The retainer washer 490 comprises a body having a first engaging face 491 for engagement with the nut member 290 and a second engaging face 492 for engagement with a work piece. The body has a central axis, with the engaging faces 491, 492 each being of annular configuration centred on that axis. The body has a radial outer periphery 493 and a radial inner periphery 494 defining a central aperture for receiving the projection portion 280 of the nut member 290 with a clearance fit therebetween, as best seen in Figure 21.

The nut member 290 and the retainer washer 490 are in facing engagement through their respective engaging faces which incorporate a ratchet mechanism allowing rotation of the nut member in the tightening direction while providing controlled rotation in the unscrewing direction. The ratchet mechanism is similar to that operating between the nut assembly 100 and retainer washer 490 of the earlier embodiment.

The retainer washer 490 of this embodiment is configured to exhibit the elastic behaviour of the elastic joint element 490 of earlier embodiments. In this regard, the annular body of the retainer washer 490 incorporates the flange portion extending inwardly at the inner periphery of the body to extend around the central aperture, and the curved configuration of the face 492, as was the case with the earlier embodiment.

Referring now to Figure 24, there is shown a threaded fastener assembly incorporating a plurality of elastic elements arranged in series. In this embodiment the elements are of dished configuration, as shown in the drawing, to facilitate self-centring one with respect to another in the series.

Referring now to Figures 25 and 26, there is shown a threaded fastener assembly according to a still further embodiment. The threaded fastener assembly is similar to that of the second embodiment, with the exception that it incorporates an arrangement for providing an indication of the extent to which the threaded fastener assembly is loaded. For this purpose, the nut 100 incorporates a pointer 060 on the second member 590 thereof. The pointer 060 operates in association with a scale 050 marked on an exposed portion of the elastic element 490. The pointer 060 and the scale 050 can be used to determine the extent to which the nut assembly 100 is tightened after coming into frictional engagement with the elastic washer 490. This can be useful to establish a prescribed preload, with the preload being accurately determined by the extent to which the nut is rotated after initial frictional contact with the elastic washer.

Because of the ratchet mechanism operating between the second nut member 590 and the washer 490, there is a "clicking" noise generated upon rotation of the nut relative to the washer in the tightening direction after initial engagement therebetween. Such "clicking" noise can be utilised to regulate the extent of preloading of the fastener assembly. This can be done, for example, by specifying that the tightening procedure should be to a prescribed number of "clicks" in the assembly. For this purpose, there can be used an acoustic pick-up or detector 800 which, in combination with an amplifier and a speaker, or a counter with a display, or any other appropriate device, can aid precision loading of the assembly by counting the number of "clicks".

In the embodiments previously described, the threaded fastener assemblies utilised single-start threads. Other arrangements are, of course, possible. By way of example, Figure 27 illustrates the first member of a nut of two-part

construction, with the first member being internally threaded using a multiple-start thread.

To improve performance of the assemblies, friction-reducing measures can be implemented. They might include a variety of lubricants on some or all internal assembly surfaces and also on the thread. For bigger fasteners, it may be advantageous to introduce roller bearings 020 with two-part cages as shown in the embodiment of Figure 28. The lower part of the cage centres on the retainer washer but is allowed to rotate relative to the retainer washer. The cage components can be spot welded or assembled using fasteners such as rivets.

An elastomer seal may be fixed to the middle washer. It rotates relative to the lower washer and moves up and down as rollers move on ratchets.

Roller bearings can also be placed in grooves on one of the interacting structures and allowed to rotate on the opposite structure's ratchets.

The embodiments have been described with ratchet ramps of one type of construction. It should be appreciated that the ratchet ramps can be constructed in any appropriate way. An alternative form of construction of ratchet ramps is illustrated in Figure 29 of the drawings.

From the foregoing, it is evident that the various embodiments provide a simple yet highly effective threaded fastener assembly which can be readily assembled and disassembled, and which can resist vibration and dynamic loads, as well as thermal variations. A particular feature of the threaded fastener assembly providing such characteristics is the use of the elastic element (washer). The elastic washer is in facing engagement with the fastener element (nut or bolt) through a ratchet mechanism, as described. The ratchet mechanism in conjunction with the elasticity of the elastic element serves to function as a clutch, allowing rotation of the fastener element in the tightening direction and inhibiting rotation in the loosening direction.

While the embodiments have been described with reference to the elastic element forming part of the particular threaded fastener assembly described and illustrated, it should be understood that the elastic element itself may also have applications in other threaded fastener assemblies.

Improvements and modifications may be incorporated without departing from the scope of the invention.

Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

Dated this First day of July 2003.

Eznut Pty Ltd
Applicants

Wray & Associates
Perth, Western Australia
Patent Attorneys for the Applicants

Fig. 01

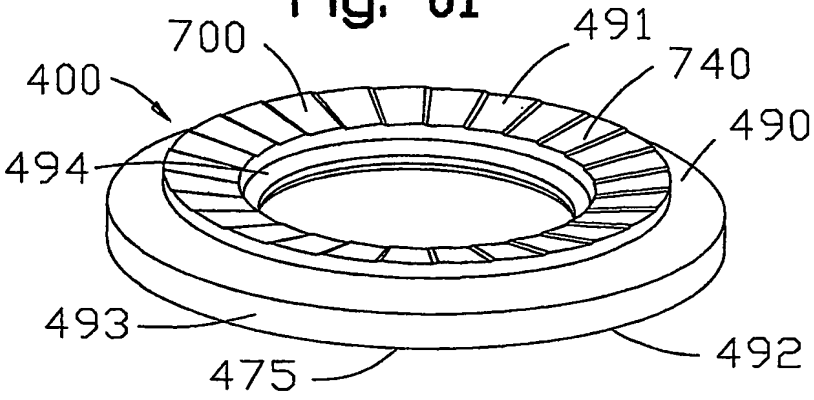


Fig. 02

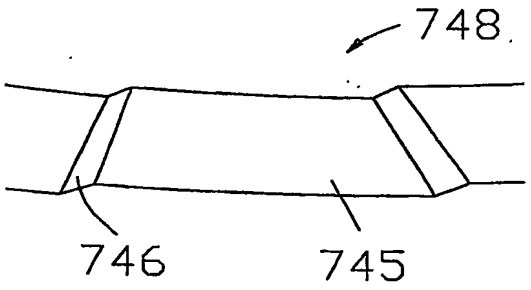


Fig. 04

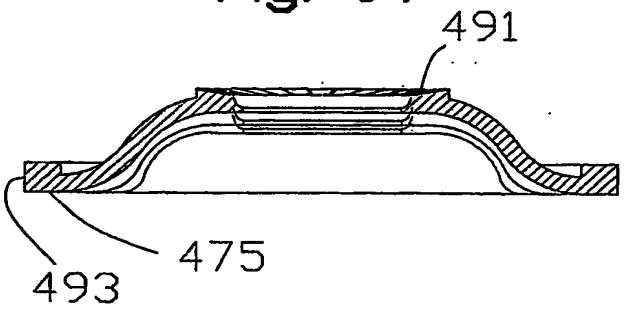


Fig. 03

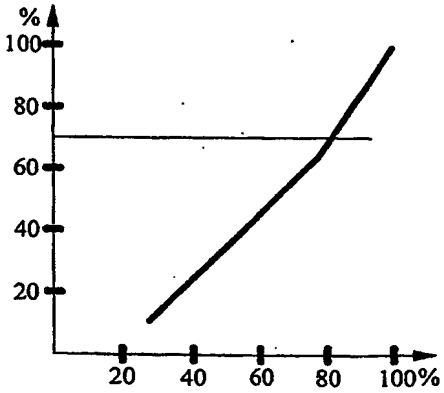


Fig. 05

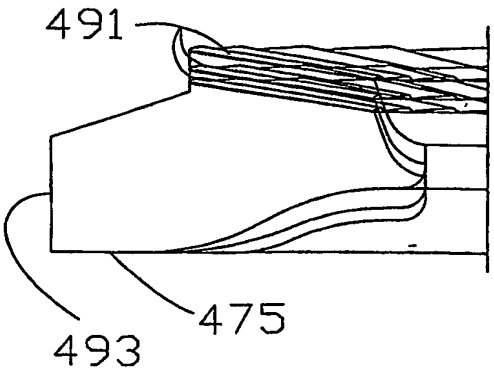


Fig. 06

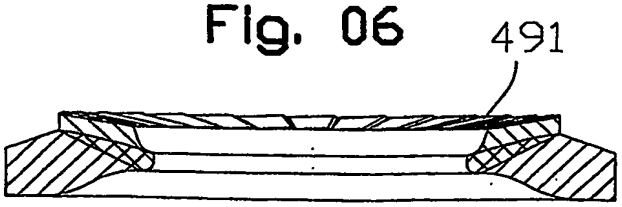


Fig. 08

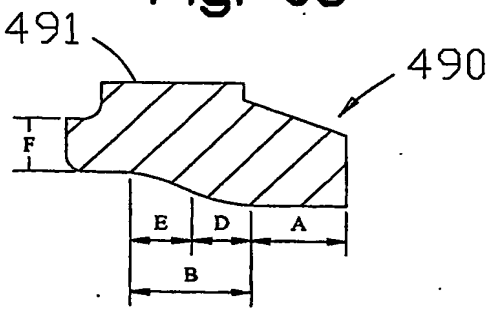


Fig. 07

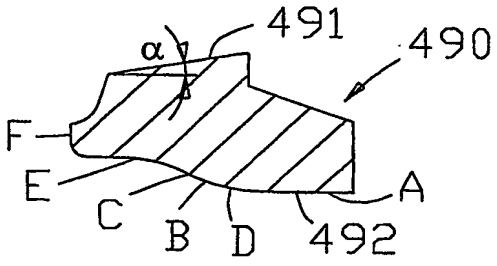


Fig. 09

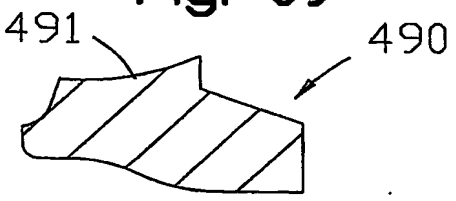
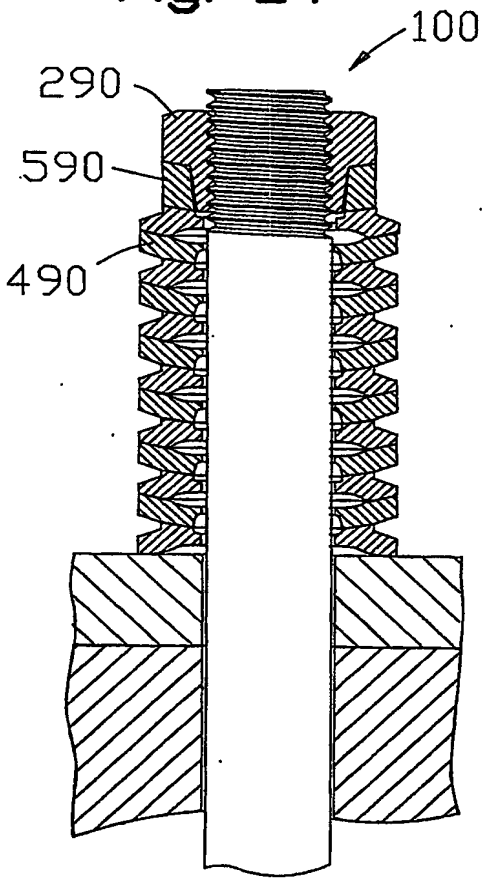


Fig. 24



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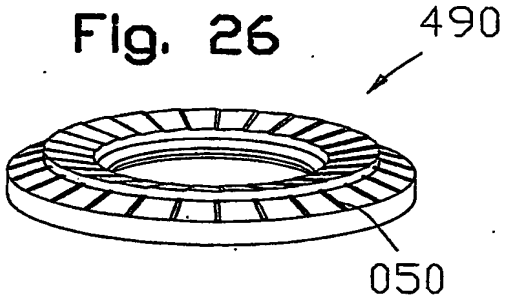

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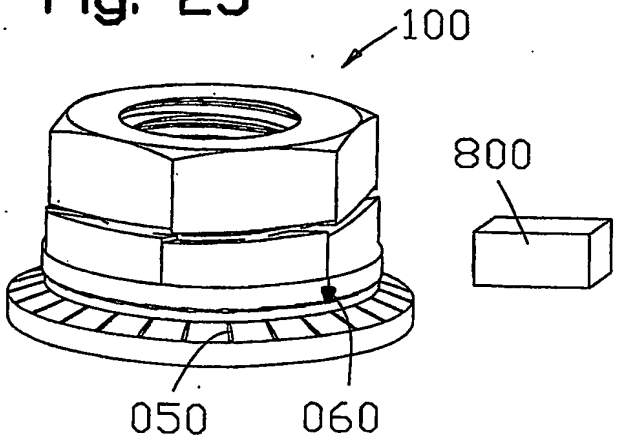

Fig. 10

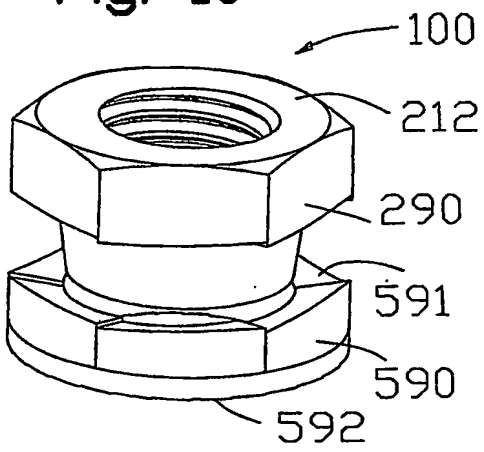

Fig. 11

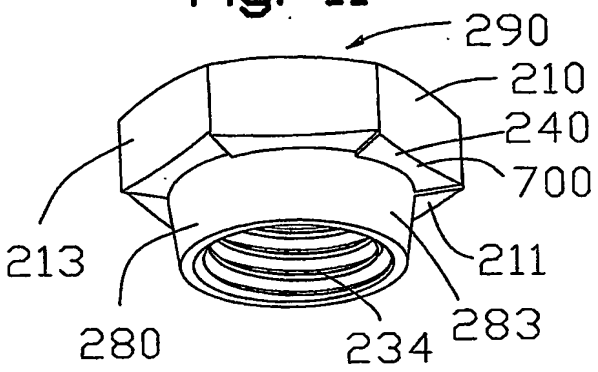

Fig. 19

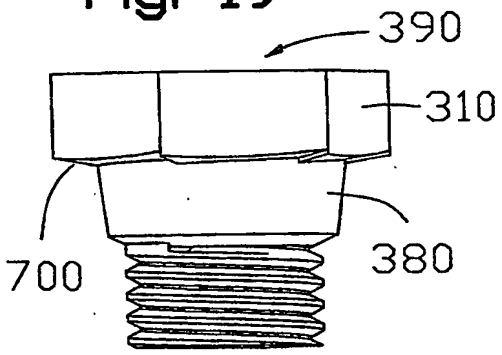

Fig. 12

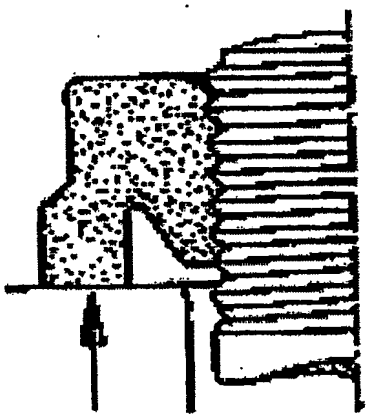

Fig. 13

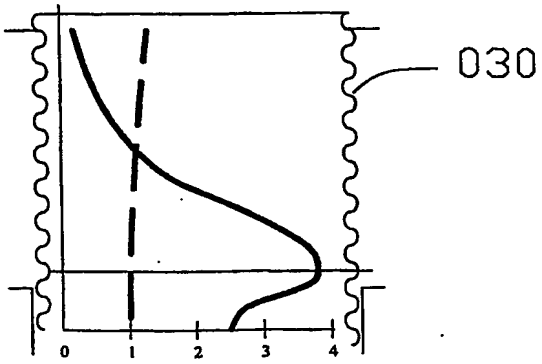

Fig. 14

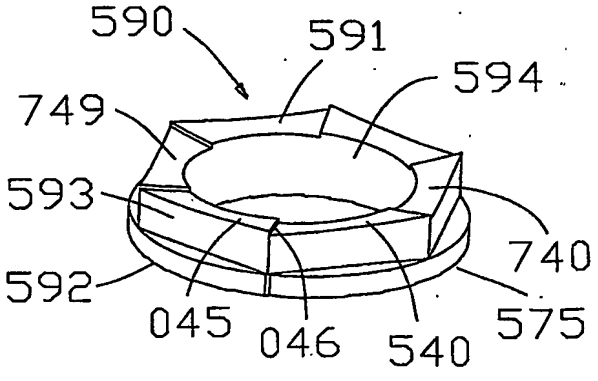

Fig. 16

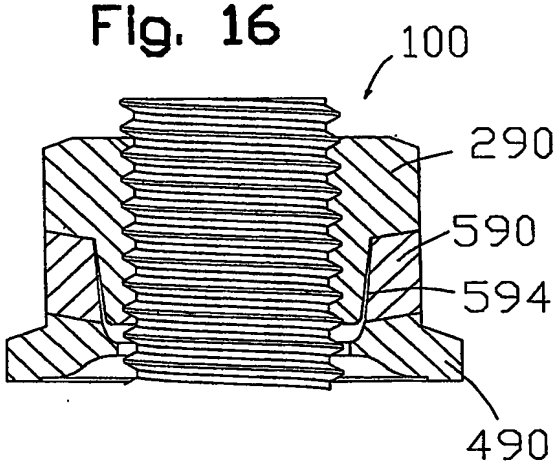

Fig. 15

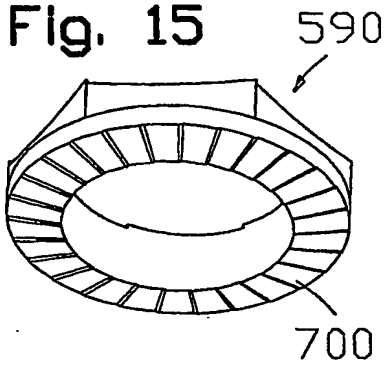

Fig. 17

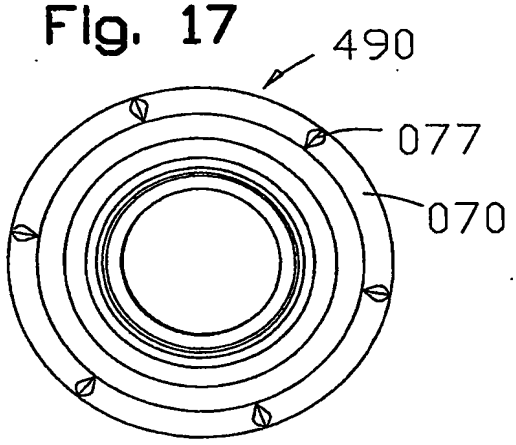

Fig. 20

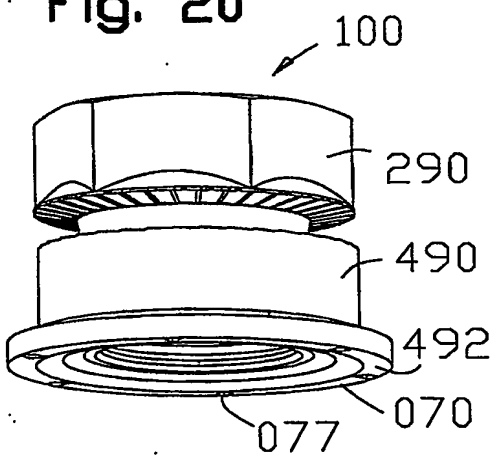

Fig. 22

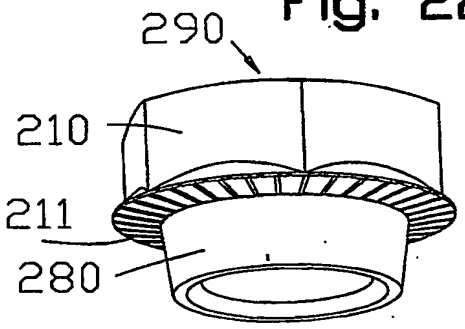

Fig. 21

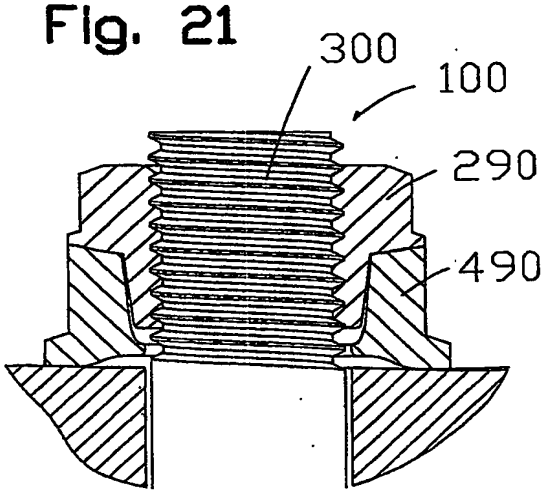

Fig. 23

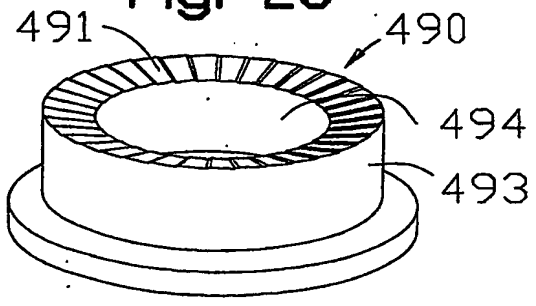

Fig. 27

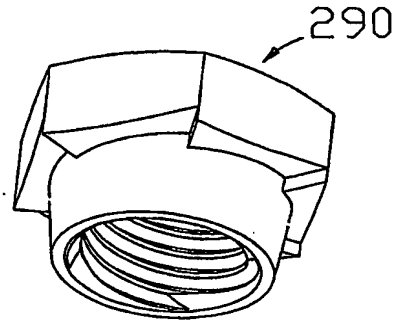

Fig. 28

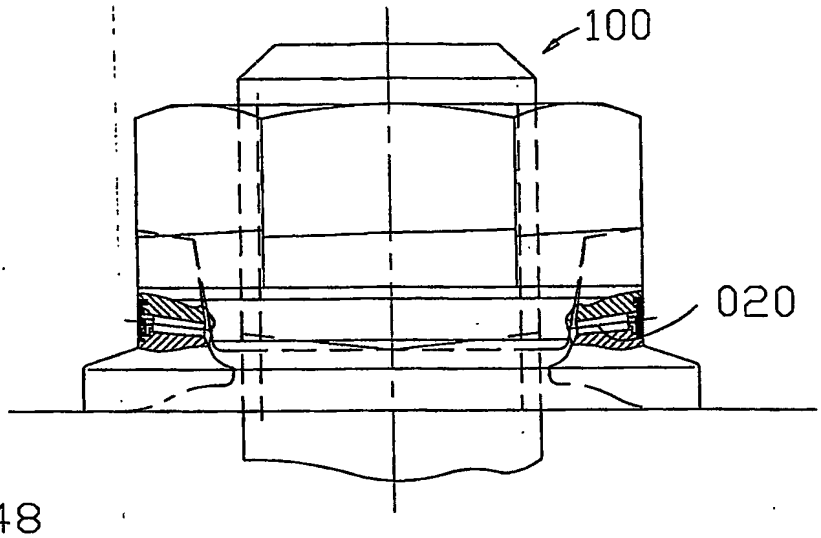

Fig. 29

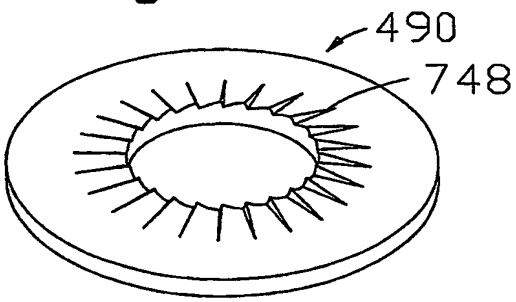

Fig. 18